

C. Geochronology based on Volcanic Ejecta and its Contributions to Archæology in Japan

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The different regions of the world, each has its characteristic keys to its geohistory; for instance, land in high latitudes have glacial topography and glacial deposits; periglacial regions have loess deposits; the bottom of the ocean has a complete sequence of deep-sea sediments and so on. In Japan, as in many places of the volcanic zones on the earth, among the suitable keys to solve the Quaternary history, the important one is volcanic ejecta.

Pyroclastic volcanic ejecta was called *tephra* in Greek, and geochronology based on volcanic ejecta was called *Tephrochronology* by Professor Thorarinsson of Iceland, whose terms I prefer to use, instead of 'Pyroclastic volcanic ejecta' and 'geochronology based on volcanic ejecta'.

In Japan, after World War II, tephrochronological studies have made great progress in various fields of Quaternary research, such as prehistory, stratigraphy, geomorphology, pedology, volcanology and so on. I give here a brief review of the recent progress in the particular fields of prehistory, stratigraphy and geomorphology in Japan, thanks to tephrochronology.

Japanese prehistoric studies have made remarkable progress, though it was not until 1949 that the existence of Palæolithic remains in Japan was known. During the past several years a great many stone implements not associated with Jōmon pottery have been discovered in many parts of the country. Moreover, radiocarbon dating shows that the beginning of the Jōmon ceramic period may be as long as 9,000 years ago. Therefore, the possibility was recognized that almost all Japanese preceramic stone implements are of the Pleistocene age.

As many of these preceramic stone implements were found in the tephra layers, tephrochronological studies helped to determine their precise chronological position.

Stratigraphy and geomorphology studies of climatic change and glacial eustasy of sea-level have been made concerning the Quaternary strata and terrace topography. This field had been almost entirely neglected before the war, because complicated crustal movements during the recent geological period made it difficult to distinguish the effect of these changes. For example, some coastal terraces from 20 to 40 metres high are considered to be the result of eustatic upheaval of sea-level during the last interglacial age. On the other hand, some submarine terraces of about 100 metres below the present sea-level are thought to be correlated with the eustatic lowering of sea-level during the last glacial age. Here, as in the case of prehistory, tephrochronology has proved itself to be valuable. Many terraces scattered in Japan have been correlated with each other by the use of tephra layers, and even the chronological contemporaneousness of formation of some glacial cirques in the high mountains and some terraces along streams have been established.

To give a short explanation of the method of tephrochronology, may it be said that a violent eruption of a volcano scatters a vast amount of tephra, and that the finer and the lighter the volcanic ashes, the more widely they are distributed. Therefore, using such a widely distributed tephra layer as a chronological key bed, many kinds of prehistoric objects situated just below or just above the tephra layer can be treated in relation to their positions, although these objects are far apart from one another. Moreover, if the absolute or relative age of the tephra layer has already been determined in some way, these prehistoric objects can take their proper position in the earth's history.

To determine the absolute or relative age of the tephra layers, various methods have been examined in Japan. Literary records of volcanic activities are used frequently to determine the days of the tephra layers deposited in historic time. Tree-ring analysis, radiocarbon dating, the rate of sedimentation of peat bogs are applied to calculate the age of the tephra layers. Prehistoric objects, especially Jōmon pottery, pollen diagrams, the standard terraces and the standard Quaternary strata are also used to determine the relative ages of the tephra layers.

A new method, worth noticing, is that of palæomagnetism. It measures the magnetic polarities of tephra itself, and is being used by some geologists to correlate the tephra layers far apart from each other; this method is however still in a trial stage.

Among the contributions of tephrochronology to the progress of archæology in Japan, the following need be said.

Many volcanoes in Japan erupted violently during the Pleistocene and some of them even in the Holocene. Accordingly, Jōmon remains and pre-Jōmon or preceramic remains have frequently been discovered in tephra layers.

As previously stated, Japanese prehistoric objects, especially the well-known, typical Jōmon pottery, were used to determine the age of tephra layers. But, if the prehistoric remains or sites contain nothing of well-known typical industries, the dating of the remains or sites must depend upon a study of the stratigraphic horizon. Numerous preceramic stone implements have been discovered in tephra layers, but the absolute or relative age of these preceramic stone implements would not yet have been determined, if it were not for tephrochronology.

In the Kantō Plain, on the central part of which Tokyo is situated, many pre-ceramic stone implements were picked up from the tephra layers called Kantō volcanic ash or Kantō Loam. The Kantō Loam is divided into three or four layers, mainly by the buried soil or fossil soil horizons. Preceramic stone implements of point and knife-blade industries have been discovered in the Upper Kantō Loam layer, which immediately underlies the humus horizon; while the stone implements of blade and hand-axe industries have been found in the buried soil just below the Upper Loam layer.

According to the studies of terrace topographies of the Kantō Plain, the lower terraces covered with the Upper Kantō Loam were built during the remarkable depression of sea-level, which was caused by eustatic depression during the last glacial age. Therefore, the Upper Kantō Loam is believed to be the layer accumulated during the last glacial age. Moreover, the age of plant remains in the Upper Kantō Loam has been determined to be about 24,000 years ago, by radiocarbon

dating. Consequently, the age of stone implements of point and knife-blade industries must be in the Wisconsin glacial period.

Some features of the natural environment of the prehistoric past, dated by tephrochronology are being revealed with the aid of other studies. For example, in the Kantō Plain, pollen analytical studies of peat bogs come to the following conclusions: the buried soil horizon which immediately underlies the Upper Loam and contains the blade and hand-axe industries was developed under the occurrence of coniferous forest, that is under a colder climate than that of the present.

Tephrochronology has already proved itself very useful for purposes of archæological dating in Japan. This method will be even more used in the future and can well be applied in the volcanic areas of Southeast Asia, as it is being applied in New Zealand.